

MisophoniAPP: Person-Centric Gamified Therapy for Smarter Treatment of Misophonia

Rachel Noziglia¹, Troy McDaniel¹, Derrick Anderson², Ramin Tadayon¹, and Sethuraman Panchanathan¹

¹Center for Cognitive Ubiquitous Computing, CIDSE, Arizona State University, Tempe, AZ

²School of Public Affairs, Arizona State University, Tempe, AZ

Abstract: Misophonia is a newly-classified chronic psychiatric condition in which an individual experiences highly-negative reactions to “trigger” sounds that do not affect others. In this work, a website has been developed, entitled “MisophoniAPP”, as a person-centric serious game which provides a relaxing environment for the treatment of misophonia through exposure therapy. Using highly customizable gameplay and an interface that allows users and administrators to set individualized goals and rewards, as well as data monitoring to track an individual’s progress, MisophoniAPP addresses the challenge posed by conventional Cognitive Behavioral Therapy and Neural Repatterning Technique approaches, which often only assist a limited subset of the misophonia population.

1. INTRODUCTION

Imagine hearing the distant chirping of birds in the surrounding trees on a calm, spring day. Now imagine feeling so disoriented by this simple sound that you have no choice but to run away in a panic. This extreme reaction is characteristic of the chronic condition of misophonia, wherein everyday sounds can become extremely unpleasant and lead to damaging effects on an individual’s health and well-being. Misophonia is, by nature, an individually variant condition; the causes, aggravators, and effects or symptoms of the condition may vary significantly from person to person [1]. These symptoms may range from mild discomfort or unpleasant sensations to more severe reactions including extreme anger or panic. Unfortunately, there is not yet a known cure for the condition, and even under the treatment options currently in place for individuals with misophonia, results may vary. Furthermore, even among these treatment options, few exist that give the individual a sense of control over his or her own treatment, a crucial part of smart living. To address these limitations, this work explores the development of a person-centric approach to the treatment of misophonia through a customizable and web-accessible serious game.

1.1 Misophonia Overview

Some of the latest investigations on the prevalence of misophonia have estimated that it impacts roughly 15 percent of the adult population in the U.S. [2]; however, the exact number is yet to be determined, as its classification is relatively recent. Furthermore, the classification itself is under heavy discussion as it has not yet been determined whether it should be considered an independent condition or attached to other psychiatric disorders [3]. Perhaps the most well-established characteristics of misophonia to-date are that it is initiated by unpleasant sounds called “triggers”; that the resulting physical response is perceived as uncontrollable and involuntary; and that the trigger sound is something which others may not find unpleasant, e.g., chirping birds [4].

Misophonia can have a significantly negative impact

on how well an individual is able to function in the world. For example, to avoid the symptoms of the condition, an individual may opt to avoid situations in which the trigger sound is likely to occur, including social interactions. Anxiety, disgust, and discomfort are often experienced in mild cases [5], and in more serious cases, the individual may act out in anger, fear, or panic to eliminate the noise [6]. The trigger noises and the effect they cause depend on the individual; however, some sounds that are commonly found to be triggers among diagnosed individuals include noises of the mouth, throat, nose, and feet; slamming doors; writing on and rustling papers; cricket noises; and more [7]. The nature of the trigger noise may be so specific that it is only encountered from a single source in some cases, such as a specific person known by the individual [8]. One critical finding is that this syndrome is a conditioned or learned response to sounds, which suggests that it can be treated in a similar manner [8]. While it has been concluded that an individual may accumulate several triggers throughout a lifetime, it is also suggested that treating the individual against existing trigger sounds may incur the additional benefit of preventing further triggers from being accumulated.

1.2 Person-Centric Approach

Due to variation in symptoms and causes for misophonia between individuals, to be widely effective, treatment may focus on the individual, rather than treating it as a general condition. This philosophy of design applies directly to technology-based treatments as well. The paradigm of Person-Centered Multimedia Computing (PCMC) [13] establishes that individual preference, goals, and characteristics should be reflected in the design of effective modern technology for assistance, health care and rehabilitation due to inter-personal (and even intra-personal) variability. This is achieved by designing methods to empower users to mold solutions to their own specific needs and circumstances. Hence, in the design of a serious game to treat misophonia, it is proposed that by including this customizability, which has been found lacking in other approaches that have seen limited success, the game can be more widely applicable and more effective.

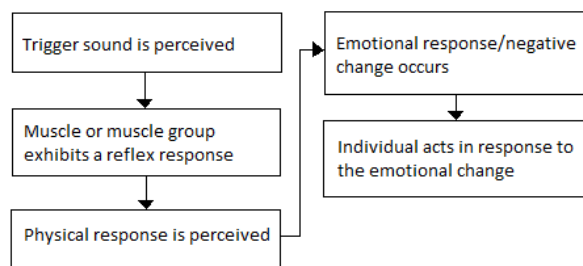


Fig. 1 Misophonia Reaction Process

2. RELATED WORK

2.1 Treatment Techniques

A fairly comprehensive set of current methods for treating and managing misophonia is provided in recent work by Tom Dozier, Director of the Misophonia Treatment Institute [8]. Two of the most successful techniques utilized, Progressive Muscle Relaxation (PMR) and Neural Repatterning Technique (NRT), are referred to in this work and summarized in Table 1. Partially as a consequence of the recency of misophonia's classification, and perhaps partially due to lack of wide applicability of existing treatment options, many individuals opt to temporarily alleviate symptoms rather than to address the issue at its source. Techniques for temporary relief generally attempt to ease the process of eliminating the triggering sound from the individual's hearing channel. Noise-cancelling headphones are a common solution, which do not reduce an individual's reaction to a trigger with time.

One key finding in Dozier's work that has aided the establishment of treatment for misophonia is that the initial response to a trigger is usually physical [8, p.52]. That is, one or more muscles in the body often exhibit a reflex response when the trigger is perceived, and the emotional response follows this reflex. Many muscle groups and areas have been identified as reflex responses in misophonia, including but not limited to the neck, shoulders, face, chest, arms and hands, thighs and calves, and more, often in conjunction [8, p.127]. The process is illustrated in Fig. 1. This finding is significant because it also leads to the exploration of physical reflex response removal as a treatment, under the logic that if the reflex response precedes the emotional and psychiatric symptoms, then this may comprise a stimulus-response reaction, and therefore removing the physical response with treatment may remove or reduce the emotional response [8, p. 101].

Table 1. Misophonia Treatment Methods (from [8])

Name	Strategy	Procedure
Progressive Muscle Relaxation (PMR)	Reduce or eliminate reflex response	Muscle relaxation techniques, interventions and medication
Neural Repatterning Technique (NRT)	Retrain the emotional response	Weak trigger integrated into positive or pleasant context

Various techniques have been developed [8]. The first is Progressive Muscle Relaxation (PMR). In this technique, a subject is trained to relax the muscles associated with his or her reflex response, with the understanding that when a trigger occurs, it is far easier to control and prevent a reflex response on a relaxed muscle than one that is tense, which would then reduce the emotional effect. Strategies to achieve this relaxation include introducing distraction stimuli such as tickling that interfere with the response pattern [8]. However, from a technological perspective, since the targeted muscle areas and groups differ from individual to individual, and may change over time for an individual, and since techniques for relaxation and intervention may vary drastically depending on the muscle group or area targeted by the approach, it is difficult to apply PMR alone in a person-centric design due to the challenge of developing a consistent interface. Furthermore, the technique, by itself, may be somewhat more invasive than others depending on the severity of the muscle response, which is less desirable for software deployed in a smart environment aimed at giving the individual a sense of control over therapy.

A second technique, called the Neural Repatterning Technique (NRT), focuses the therapy on retraining the emotional response rather than treating the physical response. The strategy in NRT is to integrate a weak version of the trigger within an environment, stimulus or context perceived by the individual as pleasant or positive [8, p.103]. The physical reflex response is still present, but as the timing and strength of the trigger are under careful control, the strength of the reflex response can be controlled as well. The goal is that the reflex response can be gradually associated with a positive emotional response, remapping the neural process in such a way that negative effects of the trigger sound can be alleviated [8, p.105]. NRT is readily applicable within a non-invasive technological approach such as a serious game as there is already ample evidence that games can be designed to elicit a targeted emotional response in an individual [14]. Furthermore, serious games can give an individual a sense of control over the therapy [15], which is a crucial element of health care in smart living contexts. However, a person-centric application of NRT, which customizes the software's approach to the individual, has yet to be explored.

2.2 Apps and Software for Misophonia Treatment

Due to the recency of misophonia's classification, few technological apps and software have been designed as treatment options. Those developed by Dozier are reviewed here, as well as their current limitations which MisophoniaAPP aims to address. In [9], the "Misophonia Reflex Finder" is an app aimed at assisting an individual in identifying the physical reflex response associated with a trigger. Identification of this physical response is a crucial element of both PMR and NRT, since PMR aims to directly treat this reflex and NRT aims to retrain the response to the reflex. This app is useful as a first step in a person-centric treatment

approach but does not otherwise assist with treatment of the condition on its own.

In addition, Dozier developed the “Misophonia Trigger Tamer Plus” app [11] which utilizes audio files with pleasant sounds to deliver a form of software based NRT to an individual. A set of short-duration, low-volume trigger sounds is combined with a set of pleasing tones and audio cues to assist an individual in gradually associating the physical reflex with a more positive emotional state. Delivery of the two sets of audio cues is mixed into a single audio stream such that the triggers are integrated within the positive context of the pleasant audio. The “Trigger Tamer Plus” includes several customization options, including the ability to select and upload specific trigger sounds and pleasant audio sounds into playlists or choose from a preset (in the case of pleasant sounds), and to customize the length, interval, and other properties of the trigger noise, which are essential in a person-centered design approach.

However, there are several limitations to this app that MisophoniAPP aims to address: the first is the lack of a method for progression toward an external reward beyond listening to the pleasant audio. An external reward can serve as a strong motivator and higher-level goal to incentivize continued usage of the app over time since the improvement is a gradual process [16]. Furthermore, apart from listening to the audio, the app can benefit from a focused, pleasant activity to create a meaningful context of interaction [17]. Finally, a crucial element of smart living is self-access to an individual’s health-related information [18].

3. METHODOLOGY

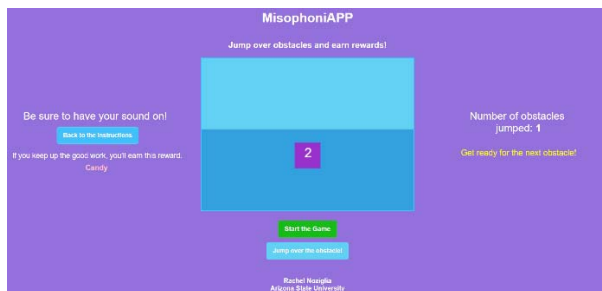


Fig. 2 MisophoniAPP Main Game Screen

Based on the achievements and limitations of the latest apps, a web-based serious game app, MisophoniAPP, has been developed as a person-centric, smart-living focused approach with three purposes: enable individuals with misophonia to take greater control over their therapy with access to a highly-customizable and fun treatment experience; provide access to data on treatment progression through performance data monitored and displayed within the app; and collect this data across a wide variety of individuals such that patterns and stimuli that are found to be commonly successful across the population can be identified over time. The current prototype is deployed on the Angular platform using a Node.js/Express server

with database storage using PostgreSQL, and as such, is accessible through a variety of interfaces.

3.1 Game Design

The main game screen of the app is shown in Fig. 2. The gameplay consists of a very simple timed challenge in which a moving colored square approaches the subject from a horizon, and the subject must “jump over” the square by pressing a button at the correct time. A countdown timer is displayed on the square to assist with the timing of the jump. When the user jumps over the square, a random sound is played from a playlist set that includes both trigger sounds and pleasant audio selected by the user in a similar manner to [11]. This interaction comprises a single round. For one session of the game, a set number of rounds (customized individually for the subject) appear one after the other in this manner, and the user must clear as many of the rounds as possible until the level completes. Positive messages are displayed to the user upon successfully jumping over a square, such that even in the case of a trigger audio playing, a positive and rewarding environment encourages the subject and provides positive reinforcement in addition to the intrinsic motivation of defeating the game challenge to fulfill the main requirement of NRT.

Knowing the timing of the stimulus arrival affords the user a sense of control over the exposure to triggers. When gameplay is complete, the user reports, through a follow-up interface, the number of trigger sounds he or she perceived during gameplay, as a form of self-reporting of progress. Furthermore, the user also reports the main emotion felt while playing, from the following set: Happy, Fine, Annoyed, Uncomfortable, or Miserable. After each session, these two datapoints are collected, stored and presented back to the individual (or other supervisory administrator) to enable progress monitoring over time.

The context of “overcoming obstacles” inspired the design of MisophoniAPP’s gameplay, and is intended to elicit a positive, motivated response from users by situating the treatment within such an environment. This abstraction of therapy is a key advantage proposed by the use of a serious game in this work. Furthermore, color choices in the interface, including specific shades of blue, purple and green seen in Fig. 2, are intentionally selected as they are commonly known to have calming effects. In this scenario, the square obstacles are an embodiment of the subject’s triggers under which he or she is given a greater sense of control and self-efficacy.

3.2 Customizations and Person-Centric Design

MisophoniAPP is designed from the ground up to achieve person-centric design through customizability and access to performance data for health monitoring. This customizability can involve both the individual as well as an assisting party, called the “administrator” or “admin” for short, which can be a therapist or parent/guardian monitoring and assisting the individual

throughout the treatment process. Elements of the game that can be customized are presented in the Admin screen, Fig. 3, accessible from MisophoniAPP's main interface. These include: trigger sounds and pleasant sounds (default: all selected), which can be uploaded from a personal collection or automatically chosen from a default set, the number of rounds to be played (default: 5), the speed at which squares approach the subject (from three options, with a default of 1 or slowest), gameplay intensity on a scale from 1-10 (see section 2.3; default is 5), and an external reward label. Preset pleasant audio was selected as major piano chords based on their general association with positive emotional response [12].

One of the key reasons for involving an admin in the gameplay is the addition of an external reward or goal. In MisophoniAPP, the user or admin can include an external reward, stored in the app as text on the Admin screen and provided outside of gameplay, that the user can work toward by progressing in the game. This external reward can be decided by the admin in communication with the individual and administered by the admin once the user has reached a certain level of performance. It is proposed that in addition to the reward of completing game challenges, this external reward may serve as a person-centered reward structure so that the reward for progress can be tailored.

At any time, the user or admin can access the User Progress screen to determine the number of rounds that have been played, the "percentage of correct answers" which represents how accurately the subject reported the number of trigger sounds heard during gameplay, and the number of times the subject reported experiencing an emotional response during gameplay. This data is reported in four different time intervals: data collected over the last day, week, month and year. Admins and users can utilize this data to determine how well the user is progressing, and when appropriate to administer an external reward.

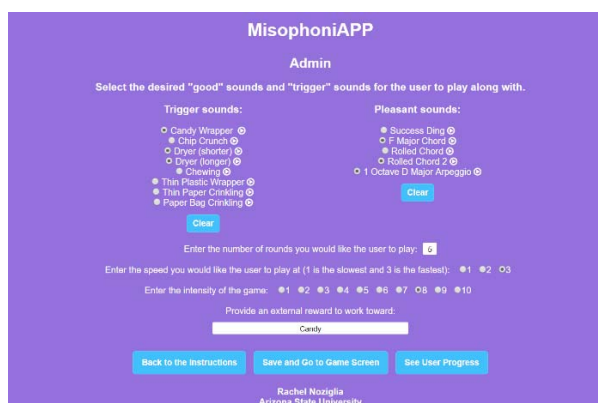


Fig. 3 MisophoniAPP Admin Screen

An admin can monitor emotional feedback to notice improvements from the previous week or month, which suggests that the subject is gaining an increased control over response to trigger sounds. It is critical to include the "percentage of correct answers" in this analysis,

since the purpose of this datapoint is to ensure that the subject is consistently hearing the correct number of trigger sounds and the audio of the game is not turned off during gameplay. If a high emotional response is associated with poor accuracy of reported number of trigger sounds that the subject experienced in a week, then it cannot be assumed that the emotional output is the result of an improvement of the subject in responding to the triggers for that week. Careful consideration of the relationship between these data during analysis can ensure more accurate assessment.

3.3 Adaptation of Game Difficulty

Customization options in MisophoniAPP include control by the user or admin over the "intensity" or difficulty of gameplay. This is critical in a person-centered approach as Flow Theory [19] suggests that setting and updating the appropriate level of challenge to the subject's level of ability can ensure the greatest efficiency of learning and highest level of engagement. In this case, difficulty can be set in a range of ten levels. Each level corresponds to the percentage likelihood in any round of gameplay that, when the subject jumps over a square, a trigger sound is heard instead of a pleasant sound. When the intensity is 1, there is a 10% chance that the next audio cue played will be a trigger, or 20% for intensity level 2, etc.

The appearance of trigger sounds and pleasant sounds is randomized to serve as an accountability mechanism in the design of the prototype. Since the number of trigger sounds is randomized, the user does not know beforehand how many trigger sounds will appear, and consequently, the audio must be turned on during gameplay so that the subject can give an accurate response at the end of the game on how many trigger sounds were heard. This design is key to ensuring that the metric of response accuracy in the User Progress Screen is reliable, and the unpredictability adds to the challenge of gameplay.

4. CONCLUSIONS AND FUTURE WORK

In accordance with the philosophy of person-centered design, MisophoniAPP's design is based on feedback from a family including an individual who had experience with misophonia. The addition of gameplay elements with full customization, an external reward which is managed outside of the app and can be set individually for each user, and data monitoring tools can allow a wide variety of subjects to benefit from the NRT approach applied by this app. Future evaluation is necessary to determine the extent of this applicability and usability across the misophonia population.

5. ACKNOWLEDGMENTS

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